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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
09/499,037	02/07/2000	Kazuhiro Aihara	49657-551	9656

20277 7590 12/18/2001

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EXAMINER	
MONDT, JOHANNES P	

ART UNIT	PAPER NUMBER
2826	

DATE MAILED: 12/18/2001

Please find below and/or attached an Office communication concerning this application or proceeding.

Office Action Summary	Application No.	Applicant(s)	
	09/499,037	AIHARA ET AL.	
	Examiner	Art Unit	
	Johannes P Mondt	2826	

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --

Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE 3 MONTH(S) FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If the period for reply specified above is less than thirty (30) days, a reply within the statutory minimum of thirty (30) days will be considered timely.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133).
- Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

Status

1)☒ Responsive to communication(s) filed on 11/29/01 .

2a)☒ This action is **FINAL**. 2b)☐ This action is non-final.

3)☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

Disposition of Claims

4)☒ Claim(s) 1-6 is/are pending in the application.

4a) Of the above claim(s) _____ is/are withdrawn from consideration.

5)☐ Claim(s) _____ is/are allowed.

6)☒ Claim(s) 1-5 is/are rejected.

7)☒ Claim(s) 6 is/are objected to.

8)☐ Claim(s) _____ are subject to restriction and/or election requirement.

Application Papers

9)☒ The specification is objected to by the Examiner.

10)☐ The drawing(s) filed on _____ is/are: a)☐ accepted or b)☐ objected to by the Examiner.

Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).

11)☐ The proposed drawing correction filed on _____ is: a)☐ approved b)☐ disapproved by the Examiner.

If approved, corrected drawings are required in reply to this Office action.

12)☐ The oath or declaration is objected to by the Examiner.

Priority under 35 U.S.C. §§ 119 and 120

13)☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

a)☐ All b)☐ Some * c)☐ None of:

1.☐ Certified copies of the priority documents have been received.

2.☐ Certified copies of the priority documents have been received in Application No. _____ .

3.☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).

* See the attached detailed Office action for a list of the certified copies not received.

14)☐ Acknowledgment is made of a claim for domestic priority under 35 U.S.C. § 119(e) (to a provisional application).

a) ☐ The translation of the foreign language provisional application has been received.

15)☐ Acknowledgment is made of a claim for domestic priority under 35 U.S.C. §§ 120 and/or 121.

Attachment(s)

1) ☐ Notice of References Cited (PTO-892)
2) ☐ Notice of Draftsperson's Patent Drawing Review (PTO-948)
3) ☐ Information Disclosure Statement(s) (PTO-1449) Paper No(s) _____ .
4) ☐ Interview Summary (PTO-413) Paper No(s). _____ .
5) ☐ Notice of Informal Patent Application (PTO-152)
6) ☐ Other: .

DETAILED ACTION

The examiner acknowledges receipt of Applicants' Amendment filed 11/29/01, in which claims 2-6 have been amended. The Amendment has been entered as Paper No. 6. Examiner's response to the Amendment with regard to Applicants' arguments therein can be found below under "Response to Arguments".

Specification

The specification does not give as much information on the tantalum nitride films as is required to understand the bounds on the chemical composition needed for the invention. In particular, on page 10 Applicant does not specify the stoichiometry as defined by x in "TaN_x", which gives the impression that the value of x is not very important. However, on the next page Applicant quotes value for the work function of the tantalum nitride films used by Applicant of 5.41 eV and 4.95 eV, which is relatively high compared with the well-known value of 2.17 eV for TaN, i.e., for x=1, and so x must significantly deviate from 1. Because the aforementioned values of the work function are important in the arguments for the usefulness of tantalum nitride as witnessed by his comparison of the work functions of different tantalum nitride films Applicant is requested to amplify on the value of x in the specification.

Claim Rejections - 35 USC § 103

The following is a quotation of 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

(a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negatived by the manner in which the invention was made.

1. *Claim 1 is rejected* under 35 U.S.C. 103(a) as being unpatentable over Alers et al (6,265,260 B1) in view of the publication by Drynan et al (ISBN: 0-7803-4774-9). With reference to Fig. 1, Alers et al teach a semiconductor device (see "Field of Invention", column 1, lines 12-14) comprising:

a via or contact plug 26 (column 3, lines 15-17) formed on a semiconductor substrate 25 (column 3, lines 13-15);

a first electrode or storage electrode 30/31 comprising a first metal layer 30 (column 2, lines 41-41 and column 3, lines 23-28) formed on and contacting an upper surface of the contact plug 26 and in a preferred embodiment allowed (column 3, lines 27-29) to include a tantalum nitride layer or film 31;

a capacitor dielectric layer or film consisting of a tantalum (pent)oxide (Ta_2O_5; with reference to Applicant's disclosure) layer or film 33 (column 3, lines 53-54) formed on and contacting an upper surface of the aforementioned tantalum nitride layer or film; and

a second electrode or cell plate electrode 34 may preferably comprise metal comprised in the first metal electrode or first metal layer 30 (column 4, lines 22-25) which metal layer may be tantalum nitride (column 3, lines 26-27); said cell plate electrode 34 is formed on and contacting an upper surface of said tantalum (pent)oxide film 33.

Alers et al do not specifically teach the aforementioned via or contact plug 26 to include a tungsten film for low resistance. However, the use of tungsten for contact plugs in semiconductor integrated circuit capacitors has long been familiar to those of ordinary skills in the art, as witnessed by the publication "Shared Tungsten Structures for FEOL/BEOL Compatibility in Logic-Friendly Merged DRAM", by J.M. Drynan et al. Specifically, Drynan et al teach the use of tungsten-based contact plugs and via plugs, especially in tantalum (pent)oxide – dielectric capacitors for DRAM devices (see abstract and Fig.3), which is the kind of Applicant's invention. Therefore, it would have been obvious to one of ordinary skills in the art to modify the invention of Alers et al so as to include a tungsten film as contact plug.

2. *Claim 2 is rejected* under 35 U.S.C. 103(a) as being unpatentable over Alers et al (6,265,260 B1), referred to hereafter as Alers1, in view of Alers (6,271,596 B1), referred to hereafter as Alers2. As detailed above, Alers1 teach a semiconductor device comprising:

a storage electrode including a tantalum nitride film formed on and contacting an upper surface of a tungsten film that is part of a contact plug, said

tungsten film being in an upper portion of the contact plug, formed over a semiconductor substrate; hence said storage electrode 30/31 including said tantalum nitride film 31 is formed on a semiconductor substrate 25;

a capacitor dielectric film including tantalum oxide film 33 formed on and contacting an upper surface of said tantalum nitride film 31; and

a cell plate electrode including a tantalum nitride film 34 formed on and contacting an upper surface of said tantalum oxide film.

Alers1 et al do not teach a copper film formed on and contacting an upper surface of tantalum nitride film 34 for improved low resistance. However, in another patent by Alers, on a capacitor structure and method of making a capacitor for use in semiconductor integrated circuits (column 1, lines 11-13, and 61-65), teaches a capacitor based on tantalum (pent)oxide as the dielectric material (hence closely related to the field of Applicant's invention), in which (cf. Fig. 3), as is the case in Alers1, the tantalum nitride layer or film 303 serves as top capacitor plate (column 5, lines 15-18), or cell plate electrode as it is called in Alers1, while a metal layer or film (numeral 308 in Alers2) is formed on and contacts the upper surface of aforementioned tantalum nitride layer or film (numeral 303 in Alers2). As possible material for the aforementioned metal layer or film Alers2 mentions copper (column 4, lines 37-40). Therefore, it would have been obvious to one of ordinary skills in the art to modify the invention by Alers1 at the time it was made so as to include a copper film formed on and contacting the upper surface of the tantalum nitride film 34.

3. *Claim 3 - 5 are rejected* under 35 U.S.C. 103(a) as being unpatentable over Alers et al (6,265,260 B1) in view of Nishioka et al (5,811,851). Alers et al teach a semiconductor device (cf. Field of Invention and Fig. 1) comprising:

a semiconductor substrate 25 (column 3, line 15);

a via, i.e., contact channel or contact plug 26 (column 3, line 15) formed on the semiconductor substrate 25;

a first metal layer or storage electrode 30 (column 3, line 26) formed on and contacting an upper surface of said contact plug;

a capacitor dielectric film including a tantalum (pent)oxide film 33 to serve as dielectric capacitor layer (column 3, line 53) and, by virtue of the optional nature of layer 31 (cf. column 3, lines 36-39 and 48-52) such as claimed by Applicants in which case the first metal layer or storage electrode is not required to comprise tungsten, formed on and in contact with aforementioned storage electrode 30; and

a second electrode or cell plate electrode 34 formed on and contacting an upper surface of said tantalum (pent)oxide film.

Alers et al do not necessarily teach electrodes 30 and 34 to include a film of indium oxide and the contact plug 26 to include tungsten. However, indium oxide is a widely used electrode material for its high electric conductivity and transparency, as evidenced by Nishioka et al who teach the use for indium oxide as electrode material in semiconductor capacitor art, hence art closely related to the invention: in particular, Nishioka et al teach a storage electrode including an

oxide film that can be an indium oxide film 46+48 (see Table in column 7, under 46 Ruthenium, listing indium oxide as other alternate example for layer 46 and see column 8, under 48, listing indium oxide as alternative example for layer 48); while an upper electrode or cell plate electrode layer or film 44 that can include an oxide film and thus a forteriori an indium oxide film (see Table in column 8 under 44, listing oxides, a forteriori indium oxide, as alternative example for layer 44) formed on and contacting an upper surface of above mentioned tantalum (pent)oxide film. Furthermore, tungsten is widely used in the art of capacitors for its high electric conductivity and refractory properties, and is recommended to be used by Nishioka et al for plug 34. Therefore, it would have been obvious to one of ordinary skills in the art to modify the invention at the time it was made so as to proscribe storage and cell plate electrodes to include an indium oxide film and to proscribe the contact plug to include tungsten.

With regard to claim 4: Alers does not necessarily teach the semiconductor device wherein the storage electrode includes a tantalum nitride film formed beneath and contacting a lower surface of said indium oxide film for the purpose of adhesion. However, with reference to Fig. 8, Nishioka et al teach a semiconductor device (column 2, lines 1-4) comprising:

a storage electrode including an oxide film that can be an indium oxide film 46+48 (see Table in column 7, under 46 Ruthenium, listing indium oxide as other alternate example for layer 46 and see column 8, under 48, listing indium oxide as alternative example for layer 48) formed on a semiconductor substrate

30 (column 5, lines 34-35) and further including a film that can be a tantalum nitride film 46 (see Table in column 7, under 46 mentioning "Ta nitride" as alternative example) formed beneath and contacting a lower surface of above mentioned film 48. Therefore, it would have been obvious to one of ordinary skills in the art to modify the invention at the time it was made so as to include a tantalum nitride film in the storage electrode formed beneath and contacting the first indium oxide film.

With regard to claim 5: the examiner takes official notice that it is obvious to enhance the overall conductivity of the cell electrode by including in it a copper film formed on said second indium oxide film, as copper greatly exceeds indium oxide in electric conductivity.

Allowable Subject Matter

1. *Claim 6 is objected to* as being dependent upon a rejected base claim, but would be allowable if rewritten in independent form including all of the limitations of the base claim and any intervening claims.

2. The following is a statement of reasons for the indication of allowable subject matter: *specific* mention of a cell plate electrode including a tantalum nitride film between a copper film and the second indium oxide film has not been found in the literature to date. Within the context of the present invention such configuration does not seem obvious.

Response to Arguments

1. Applicant's arguments filed 11/29/01 have been fully considered but they are not persuasive. To wit:

2. Cited text on the work function of tantalum nitride is strictly incorrect, although "TaN" is often used as an abbreviation for "TaN_x". This distinction matters here, because the work function is a sensitive function of the stoichiometry, as explained in the objection against the specification. Arguments by Applicants are thus considered moot.

3. In response to applicant's argument that there is no suggestion to combine the references in the rejection of *claim 1* under U.S.C. 35, 103(a) over Alers et al in view of Drynan et al, the examiner recognizes that obviousness can only be established by combining or modifying the teachings of the prior art to produce the claimed invention where there is some teaching, suggestion, or motivation to do so found either in the references themselves or in the knowledge generally available to one of ordinary skill in the art. See *In re Fine*, 837 F.2d 1071, 5 USPQ2d 1596 (Fed. Cir. 1988) and *In re Jones*, 958 F.2d 347, 21 USPQ2d 1941 (Fed. Cir. 1992). In this case, the purpose of the use of tungsten as a preferred material for a/o plugs as stated by Drynan for its low resistance (see abstract) in capacitor interconnect structures carries over immediately to the invention of the plug in the capacitor structure by Alers et al. Low resistance combined with high-temperature resilience (refractory property) is a well-known advantage for capacitor metal, largely explaining the popularity of tungsten in this art,

irregardless whether the capacitor plug material is in contact with a tantalum nitride film as claimed by Applicant or not. It is noted that the overall resistance has to be low and the high-temperature resilience has to be high within the metallic parts of the capacitor, while across the dielectric degradation of the insulator should be avoided; whence the obviousness to combine the desirable work function properties of the tantalum nitride with tungsten in the plug area, where the work function properties are not as crucial. Many other examples could have been given of the wide use of tungsten as capacitor metal including plug material, both in the patent literature and in the textbook and journal literature. Therefore, the traverse of said rejection of claim 1 is found to be unpersuasive.

4. On the traverse of rejection under 103(a) of *claim 2* over Alers1 in view of Alers2: Alers2 teaches, as shown by column 4, lines 37-40 the use of either tungsten or copper as plug material. Please note that the cell plate electrode in Alers1 is covered by a tungsten plug 35 (column 4, lines 25-26) while Alers2, through the aforementioned text, teaches that specifically copper may also be used for the "tungsten plug" 801 while exhibiting a "tungsten plug" 308 on top of the cell plate electrode 303. As mentioned before, low resistance is highly preferable and hence both copper and tungsten are often used interchangeably in capacitor metal components; copper having better thermal conductivity, tungsten having better high-temperature resilience.

5. With regard to the rejection under 102(b) of *claim 3* as anticipated by Izumi et al: no detailed comments on the traverse are required, because, based on said rejection, Applicants have amended claim 3 in a substantial manner. However, it should be noted

that counter to Applicants' assertion no direct reference was made by the examiner to column 6, lines 34-50 in Izumi et al. Furthermore, as is well known by those with ordinary technical skills in the art, the diffused regions 2 and 3 are merely the source and drain regions of the semiconductor substrate, thus forming part of the semiconductor substrate.

6. With regard to the rejection under 102(b) of *claim 4* as anticipated by Nishioka et al: no detailed comments on the traverse are required, because, based on said rejection, Applicants have amended claim 4 substantially, directly and indirectly through amendment of claim 3 on which claim 4 depends. However, attention should be drawn to the listing of nitride and tantalum, as well as combinations of nitride and tantalum as material for 34 (see column 7, lines 23, 28, and 39). Also, as Nishioka et al show there is substantial equivalence between different material choices; Nishioka et al have included several in their patent, among which those that have been claimed by Applicants.

7. With regard to the rejection under 103(a) of *claims 5 and 6* no detailed comments are necessary because both claims have been substantially amended, directly and indirectly through amendment of the independent claim. No additional specific arguments for traversing the original rejections have been addressed by Applicants, other than those referring to the traverse against the independent claims. However, the amended claim 6 now seems allowable, based on an updated search, and in view of the considerably amended claim 3 on which claim 6 depends.

Conclusion

3. Applicant's amendment necessitated the new ground(s) of rejection presented in this Office action. Accordingly, **THIS ACTION IS MADE FINAL**. See MPEP § 706.07(a). Applicant is reminded of the extension of time policy as set forth in 37 CFR 1.136(a).

A shortened statutory period for reply to this final action is set to expire THREE MONTHS from the mailing date of this action. In the event a first reply is filed within TWO MONTHS of the mailing date of this final action and the advisory action is not mailed until after the end of the THREE-MONTH shortened statutory period, then the shortened statutory period will expire on the date the advisory action is mailed, and any extension fee pursuant to 37 CFR 1.136(a) will be calculated from the mailing date of the advisory action. In no event, however, will the statutory period for reply expire later than SIX MONTHS from the date of this final action.

Any inquiry concerning this communication or earlier communications from the examiner should be directed to Johannes P Mondt whose telephone number is 703-306-0531. The examiner can normally be reached on 8:00 - 18:00.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Nathan J Flynn can be reached on 703-308-6601. The fax phone numbers for the organization where this application or proceeding is assigned are 703-308-7722 for regular communications and 703-308-7724 for After Final communications.

Any inquiry of a general nature or relating to the status of this application or proceeding should be directed to the receptionist whose telephone number is 703-308-0956.

JPM
December 10, 2001

Nathan Flynn
Primary Examiner